

A COMPARISON OF THE GALERKIN AND STABILIZED FEM FOR NONISOTHERMAL, LOW SPEED FLOWS^a

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A formulation for low speed, compressible, viscous flows has been developed that allows the occurrence of large density and temperature differences without the need to resolve the acoustic pressure field. This approach significantly extends the usual Boussinesq approximation for convective flows. The form of the proposed initial-boundary value problem is very similar to the standard incompressible flow problem; all of the approximation problems associated with incompressibility are retained in the current formulation. The primary spatial discretization method used to demonstrate the “acoustically filtered” equation set is based on a Galerkin finite element method with LBB stable elements in two-dimensions. Other discretization approaches using stabilization techniques, such as the Galerkin Least Squares (GLS) and pressure stabilizing Petrov Galerkin (PSPG) method, have also been used with the acoustically filtered equations and the same LBB elements. Fixed point iteration methods were used for solving steady flow problems and implicit, predictor/corrector integration methods were used for time-dependent solutions. In all cases, direct solvers with pivoting were employed to solve the corresponding matrix problems.

The objective in this work was to evaluate the differences in the solutions obtained via the Galerkin and stabilized formulations for the same type of finite element. Both Boussinesq and acoustically filtered equation systems were studied. Contained flows and flow-through problems under both isothermal and nonisothermal conditions were used to study the formulations. Mesh independent solutions were generated and compared in terms of both primary dependent variables and derived flux quantities.

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